

THE CASE FOR DAYLIGHTING IN ARCHITECTURE

Richard Barrett

Abstract

The paper discusses the reasons for using daylight in the design of architectural form and space. These reasons extend from those of a practical nature, including energy conservation, cost factors, and health and wellbeing, to those of a more intangible, aesthetic nature. Some historical precedents are offered as examples of projects in which designing to maximise daylighting was crucial in the mind of the architect. By contrast there is also discussion relating to the 'the lost art' of using natural lighting in architecture. Some of the reasons for this loss of conviction and expertise are considered. The place of national building codes and other statutory requirements is examined, as is the role of the architect and his/her relationship with other professionals involved in daylighting design in architecture.

Keywords

Natural lighting; daylighting; core-daylighting; form and space.

Introduction

In an earlier study conducted by the author (Barrett, 2003), the question of 'core-daylighting' was considered in reference to the natural lighting of spaces deeply within buildings - spaces that cannot readily be lit using conventional perimeter fenestration).

In considering this question, however, it was important firstly to step back from the process, and to look more broadly at the issue of daylighting per se, examining the issues, and establishing the case for ensuring quality natural lighting in architecture. There are a number of widely diverse reasons as to why this should be important. These range from pragmatic reasons, such as sustainability and energy conservation, running and maintenance costs for buildings, and the health and wellbeing of the building's occupants, to the more aesthetic and poetic aspects of architecture, such as those espoused by Le Corbusier, Louis I Khan, and a few other architects. Along those lines, Lam (1992:10) suggests that "... when all buildings were designed around a single, fixed light source (the sun) the difference between great architecture

and mere building could be measured to a large degree by the skill with which that source was used. The shapes and sizes of rooms, and the materials and details in them, were determined largely by the appearance the room would take on when rendered by daylight."

An important consideration, therefore, and one that is later discussed in more detail in this paper, is the role of the architect as compared and contrasted with other professionals working in the field of daylighting, and the various tangential issues such as user satisfaction and comfort.

The Case for Daylighting

The history of daylighting in architecture is punctuated by major developments, such as the discovery of new structural systems which allowed larger openings, and hence better natural lighting. Arguably, however, the one single event which could be considered pivotal, but also detrimental to the role of daylighting in architecture, was the invention of fluorescent lighting in the mid 1930s. This gave the architect virtual carte blanche to design deep, windowless spaces, in which lighting levels were consistent no matter where an occupant was located. No longer was the building necessarily designed to take advantage of natural light, and architects were thus deprived of an important design element, one which their predecessors had considered so vital to the crafting of their architecture.

The limitation imposed on architects of having to be entirely reliant on the sun no longer applied, and they saw the advent of efficient, uniform artificial lighting as lifting huge

constraints on their creativity. In reality, though, and as a consequence of this technological advancement, the art of using natural light in an architectural manner was rapidly lost to architects practising in the middle and second half of last century. Paradoxically, the new found freedom to design with ultimate flexibility did not, as might reasonably have been expected, give rise to better architecture. On the contrary, too many other considerations were being ignored, and above all a feeling of alienation was being experienced by the inhabitants of the new deep plan buildings.

In spite of technological developments such as fluorescent lighting, there were a few twentieth century architects for whom there could be no compromise, and who recognised the crucial role played by natural lighting in their work. As long ago as 1964, for example, Professor S.E. Rasmussen, in a series of lectures to the Royal Institute of British Architects, stated that "... the same room can be made to give very different spatial impressions by the simple expedient of changing the size and location of its openings. Moving a window from the middle of a wall to a corner will utterly transform the entire character of the room." He contended that daylight was "... fundamental in allowing us to experience architecture" (Rasmussen, 1964:187).

By way of illustration, Professor Rasmussen cites Le Corbusier's Chapel at Ronchamp, which he considers to be a major shift in thinking by the architect. Le Corbusier's earlier work he sees as employing strident, strong side lit spaces, but in the design of this chapel there is a new approach, in which "Le Corbusier has created a church interior ... which has the emotional appeal that is based on the shadowed dimness

of indirect lighting, in which form is only vaguely revealed" (Rasmussen, 1964:212-213). The architect's subtle use of natural lighting is clearly seen in Figure 1, in which the roof appears almost detached from the walls, giving the interior something of an ethereal and spiritual appearance.

The architect Louis I Khan was another strong proponent of the use of daylight in architecture; for him natural light was something of a starting point, and as contended by Buttiker "... one of the most powerful aspects of Louis I Khan's architectural space is his handling of natural light. Khan believed that architecture began with 'the making of a room', and that 'a room is not a room without natural light'. The structure is a design in light. The vault, the dome, the

arch, the column are structures relating to the character of light. Natural light gives mood to space by the nuances of light in the time of the day and the seasons of the year, as it enters and modifies the space" (Buttiker, 1994:10).

Khan sums up his own attitude in his statement that "... a space can never reach its place in architecture without natural light" (Buttiker, 1994:24).

Buttiker believes that later in Kahn's career, daylight became more and more significant in his work. He developed increasingly sophisticated ways and means of manipulating light, and according to Buttiker the zenith of his achievement is shown in one particular example of his work, namely the Assembly Hall in Dhaka,



Figure 1: The interior of Le Corbusier's chapel at Ronchamp, indicating the architect's skilful use of natural lighting (Source: www.galinsky.com/buildings/ronchamp/).

Bangladesh (Figure 2).



Figure 2: Assembly Hall, Dhaka, Bangladesh, in which Khan manipulates natural lighting to enhance the building's sculptural form (Source: Buttiker, 1994:179).

Possibly the most often cited example of Khan's work with daylight, however, is the Kimbell Art Museum, Kimbell, Texas (1967-1972). In this building he designed ceiling mounted reflectors (Figure 3) which redirect light from an exterior roof aperture running the length of the buildings.

Ander also draws upon the words of these two leading exponents of daylight in architecture, firstly in quoting Le Corbusier - "I use light abundantly, as you may have suspected. Light for me is the fundamental basis of architecture. I compose with light." And adding Khan's quote that "... a room is not a room without natural light. Natural light gives the time of day and the mood of the seasons to enter. The choice of a structure is synonymous with the light which gives image to that space ... a plan of a building should read like a harmony of spaces in light" (Ander, 1995:(ix),6).



Figure 3: Daylighting of museums and galleries is not universally favoured by curators because of risk of UV damage to the exhibits. In the case of the Kimbell Art Museum, however, and in order to minimise this risk, Khan used perforated aluminium ceiling diffuser-reflectors to admit controlled levels of natural light (Source: Buttiker, 1994:179).

Another building in which daylight plays a hugely significant part is the Johnson Wax Building, Rascine, Wisconsin (1950). The architect, Frank Lloyd Wright, carried out some bold experimentation with glass tubing to create 'skylights' to the main open plan office

area (Figure 4). Architects, like all innovators, will sometimes push boundaries beyond the knowledge and techniques available at the time, and this can be said of this project. The level of technology failed to match Wright's innovative thinking, and regrettably much of the tubing had to be replaced.



Figure 4: Johnson Wax Building, Rascine, Wisconsin, in which Wright has created a top lit interior office space at the core of the building (Source: Copplestone, 1997:70-71).

Architects who feel strongly about using natural light will sometimes describe it as being another 'material' with which to build. Ruck

(1989) emphasises the important role played by daylight in the design of architecture, and she considers it to be as much a 'material' as the brick, steel, stone and concrete, of which the solid fabric of the building is made, and should not be considered an applied decoration.

Health, Wellbeing and Performance

Gallagher (1994) suggests that the Industrial Revolution made a significant difference to the way we lived. We changed from an agrarian, substantially outdoor way of life, to a more indoor, urban environment. She believes we adapted rapidly to this new lifestyle, in spite of millions of years of evolution which had seen us respond to the cycles of the earth and sun. Gallagher states, however, that environmentally minded scientists are now questioning what we traded off in order to live indoors, with artificial lighting, heating and cooling - a new world order structured as she says around economic rather than biological concerns. For the first time in our history we were no longer awakened by the dawn, and lulled to sleep by darkness.

The availability of daylight and its impact on the health and wellbeing of building users is generally nowadays acknowledged as fact, and writing some five years later Gallagher (1999) cites winter statistics for the north of the United States, pointing out the serious nature of an illness known as seasonal affective disorder (SAD). Six percent of New York residents suffer severe depression during winter, but as many as 50% of the residents suffer mild symptoms, including low energy, and disturbed eating and sleeping patterns. Gallagher believes that this behavioural problem has a specifically environmental cause: lack of light.

Ruck is also very specific on the issue of health and wellbeing of the occupants of buildings, and suggests that "... light can also be considered on physiological and biological grounds as being essential for the wellbeing of a building's occupants owing to its non-visual effects such as brain stimulation and body orientation and balance. A good luminous environment therefore depends not only on environmental and task lighting design, but also on the spectral composition effects of the light on individuals. Great architects, including the designers of the Parthenon, the craftsmen of the Gothic cathedrals, and indeed certain twentieth-century architects, have understood the impact of natural light and its importance for putting human beings in touch with their environment" (Ruck, 1989:40-42).

It is no coincidence, therefore, that natural light has always played a key role in the design of certain building types, in particular where human emotional wellbeing could be an issue, including sacred and religious architecture. Stegers considers that "natural light... [has] a fundamental effect on the atmosphere of sacred spaces. Light and shadow determine the spatial qualities of a space ... light can accentuate, direct attention, create an atmosphere of contemplation and composure, foster togetherness in prayer, or underline the solemnity or festiveness of an occasion" (Stegers, 2008:60).

Ruck discusses the issue of human biorhythms, and the importance to human wellbeing of maintaining the 24-hour pattern. The quality and quantity of natural light plays a central role in this, and she refers to evidence indicating that seasonal physiological and psychological

problems can be caused by "the pattern of light changes in winter" (Ruck, 1989:47).

The author of this present paper visited Antarctica in the summer of 1978 as a member of the design team for the Scott Base re-building redevelopment. The continent experiences 24 hours of continuous daylight during the summer months, and it was interesting to note how people had adapted to this. The construction workers, for example, seemed to survive on far less sleep, and to work much longer shifts than normal. Hopkinson (1963) believes that both architects and the specialists they work with need to be very aware of this innate ability of human beings to adapt to environmental conditions. Whilst this may work to advantage in short term situations (such as those experienced by the Scott Base construction workers), psychological adaptation, where the person will slowly learn to tolerate conditions which he or she may have initially found to be less than ideal, may be damaging to health and wellbeing.

On this question of the 'adaptability' of human beings, Thomas (1996) makes an interesting point in regard to how we also adapt our physical environment. We do this in order to arrive at similar environmental conditions internally, regardless of external climatic conditions. He contrasts the English cob cottage with the Middle Eastern 'doha' house, both of which are constructed of earth. Both buildings, the cob cottage under overcast skies, and the doha house in bright and hot sunlight, have evolved to provide around 100 lux of light, whilst both have also dealt successfully with very differing external temperature conditions. There are, however, other considerations over and above lighting levels, and Ruck (1989) suggests that

visible light plays a much wider role than just that of stimulating 'vision'. She believes it to have a profound effect on the whole human organism. This occurs through stimulation of the pineal gland, which is connected via the inner secretory system to the endocrine glands and the central nervous system. She cites research in this area carried out by Lewy et al (1980), and points to other research, in which the psychological effects of natural light have been explored. "The information our brain receives from the illuminated environment is an essential element shaping our moods, reactions and psychological wellbeing" (Hughes 1983). Plank and Schick (1974) summarise the effect of colour on non-visual processes in human beings. The potential effects include changes in mood and emotional state, muscular activity, rate of breathing, pulse rate, and blood pressure. In addition, MacLaughlin et al (1982) have concluded that the spectral character of natural sunlight has a profound effect on the photochemistry of 7-dehydrocholesterol in human skin and induces physiological and biochemical responses in humans" (Ruck, 1989:46). Specifically, this refers to the enhanced assimilation of previtamin D3 (MacLaughlin et al, 1982).

Ander (1995) and Hopkinson et al (1966) raise the issue of preference for daylight, as generally expressed by people in the workplace, and ponder why this should be the case. At the time of writing Hopkinson et al noted that there had been little research into the behavioural aspects, and they could only therefore surmise as to the reasons. The survey undertaken as part of the author's Masters Thesis has indicated that many of the architect respondents felt issues such as exterior view and natural ventilation to

be equally important to occupant wellbeing (Barrett, 2003). Hopkinson et al reflect that same view. Gallagher believes this whole area is ripe for extensive research when she states that "... equipped with good data on which, or how many, people are sensitive to lighting, spatial arrangements, noise, and other ordinary features of our surroundings, architects, office managers, doctors, and the rest of us will be better able to create more supportive, personalised environments" (Gallagher, 1994:18).

Gallagher considers that some findings in the area of environmental-behavioural (E-B) research are significant to the debate, and Cherulink (1993), a prominent E-B researcher, agrees. He is highly critical of many architects who he sees as taking an overly quantitative approach to the planning of buildings, whilst ignoring the real needs of the users, such as their need for natural light. "Over and over again I have seen architects skip over the theory and insight of an architectural program to go straight to the square footage listing - "how big do you want the room" is the concrete level at which they are comfortable ..." (Cherulink, 1993:7).

Gallagher (1999) and Day (1990), agree with this view, believing that architects are not sensitive to the fact that the 'places' they design have a direct bearing on the mood of the users. Both authors believe that architects generally have aesthetics uppermost in their minds when designing, and that the issue of daylighting is not taken seriously; "... in every aspect of environmental design we must recognise that whatever we do affects the human being, the surroundings, the spirit of places and the wider world. It has human, social, biological and ecological implications" (Gallagher, 1999:11).

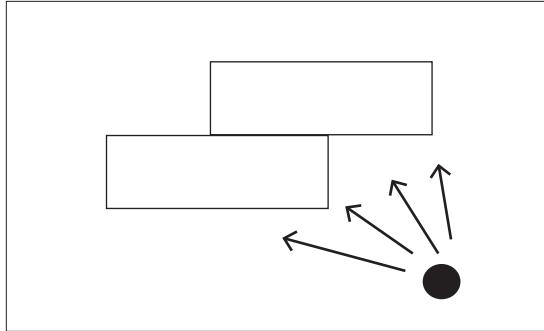


Figure 5: The geometry of plan form can be manipulated to take best advantage of sun and sky (Source: Author).

Gallagher (1994) suggests that architects are starting to respond to the growing awareness of the importance of light to wellbeing, and she cites the New York Board of Education and their experimentation with classroom shape, as shown in Figure 5, "... rather than the traditional box, this version's plan resembles a bisected square whose halves have been pushed in opposite directions; because it has eight corners and walls instead of four, the room allows for bay windows and a lot more light" (Gallagher, 1994:49).

Evans (1981) points out that the human organism works most effectively and productively when there are conditions of changing stimuli, and that by its very non-constant nature, daylight is an excellent vehicle for providing this - "... the trick in building lighting design is to find a way to provide reasonably subdued surface-brightness variations while at the same time providing some visual flexibility and stimuli. The proper introduction of daylight into the environment is the simplest and most effective way to provide

these valuable variations" (Evans, 1981:21).

Evans also points out the importance of orientation, and the fact that human beings have an innate need to be able to relate, both physically and psychologically, to their surroundings. In making the case for orientation and the need for exterior views within buildings he uses the analogy of a passenger on board ship, and points out that the passenger is more likely to suffer sea sickness below decks, than if he or she has a view of the horizon, and that (although significantly milder in effect) the same holds true for people inside buildings. Lam (1992) and Ruck (1989) also emphasise that humans have a biological need for visual information, including aspects that can be related to the daylighting of buildings, such as orientation, contact with nature, awareness of the time of day, and of the weather. Evans (1981) cites research by others such as Ruys and Sommer, in which view to the outside has been shown to be as important as sun and daylight to the occupants of buildings. He also makes the important point that duration of stay in an interior non-daylit space has a significant bearing on acceptability to the occupant. The most extreme situation of unacceptability is the totally windowless environment, which, more than 30 years ago, Collins (1975) was researching at a time when the concept was very acceptable, with the main emphasis being to conserve energy. World oil prices were soaring, and for the first time in history attitudes towards energy consumption were being challenged. The crisis caused us to look carefully at how we designed our buildings, and so it was from this somewhat pragmatic background of 'energy efficiency' that her book was published in 1975 by the US Department of Commerce. Collins believed

there was something equally important to the occupants of buildings; "... even though a windowless building might be the best solution for eliminating energy loss through windows, there is considerable evidence that this may not be very desirable for the people in the building" (Collins, 1975:2).

In the historical context of Collins' study, her cautionary warnings not to overlook the comfort, behavioural and performance needs of the occupants of buildings must have seemed anachronistic to mainstream thinking of the time. She had been right to cry caution, however, as validated by other research, including that of Rangi and Osterhaus (1999) writing a quarter of a century later, where they point to clear evidence of risk to the health of people occupying windowless environments.

Statutory Requirements and Codes

The debate about daylighting and architecture from an historical perspective shows that since the Industrial Revolution the rate of change has been exponential, and far more so than at any other time in history. The period began with the development of iron, steel and glass as major construction materials, and then moved through the discovery of various technologies that allowed the interior environment to be controlled, and culminated in the mid-twentieth century energy crisis. There was now a need to rethink much that had gone before.

Mindset, however, is always a hard barrier to break through, and this event was no exception. The commercially orientated interests of developers and clients was the overbearing driving force behind much of the architecture

built in New Zealand during the 1980s, and it was difficult for any architect wishing to address 'green' issues. In 1992, however, the New Zealand Building Code (NZBC) was adopted, and this has undoubtedly gone some way towards helping the change of mindset (NZBC, 1992, rev. 2004).

In spite of the code, however, property developers continue to look for loopholes, and the Building Industry Authority (BIA), the agency responsible for implementing the NZBC prior to 2004, regularly had to deal with situations in which interpretations were stretched beyond the point of acceptability. (The Department of Building and Housing (DBH), is the governmental body responsible for administering the NZBC since 2004. They have carried out various legal determinations which have tended to keep loophole seekers somewhat at bay).

The following is an e-mail correspondence which serves to illustrate the nature of problems being encountered by the BIA. The e-mail was received on 10 December 2001, from Ms Claire Bengé, an architect employed by the BIA in Wellington, New Zealand. It was sent in response to the author's enquiry about the NZBC, Section G7, and as to any changes to this regulation that may be being contemplated. Anecdotal information obtained by the author had suggested that some projects had been of concern to the BIA, in respect of the interpretation being taken by property developers and others.

Richard

That looks like an interesting subject, and we are very happy to help you as much as we can. As you probably know, clause G7 "natural light" requires not only natural light but also visual awareness of the

outside environment. The natural light requirement is quite low being not less than 30 lux for level for 75% for the standard year. Both of these requirements are to ensure mental health, and there is a limit on application to housing, all people's homes and early childhood centres.

One of our concerns at the moment is that developers try to get as many rooms as possible into buildings that are too deep. We receive a few queries about obtaining the awareness of the outside in deep architectural spaces through other rooms. These are sometimes for new buildings and sometimes for redevelopment of existing inner city buildings. The acceptable solution for G7 allows both natural light and visual awareness of the outside environment through another room. In practice we have interpreted this is being through a living space only. This is in order to maintain privacy, i.e. a bedroom can obtain natural light and visual awareness of the outside environment through a lounge or dining-room space because curtains can be drawn or shutters closed to provide privacy, but this does not work in reverse.

Some very convoluted plans are put to us with very little evidence that visual awareness of the outside environment is sufficient. These plans might be useful to you if we can find a way of making our correspondence available while maintaining confidentiality. If you are interested, let me know.

There has already been a ruling by the BIA about visual awareness of the outside environment, which may have cost the developer some money because the townhouses were sold as three room apartments when one did not comply with G7 and therefore strictly speaking was only a storeroom. The owners may be suing for the difference between the price of three and two-bedroom apartments.

We also have pressure from developers about the need in apartments for natural light and visual awareness of the outside environment in spaces that are likely to be used for studies, offices etc. We argue that any space that is large enough to place a bed in it is likely to be used as a bedroom at some stage of its

life and therefore must have those requirements. This would have to be a space < 1.8 in either direction.

*Claire Bengé, Architect
Building Industry Authority
Wellington
New Zealand (Barrett, 2003).*

Osterhaus and Donn (1998) compare and contrast attitudes towards daylighting and external views as apparent in a number of national building codes, including those of New Zealand, Australia, the United Kingdom, and, of particular significance, that of Germany. The fact that access to both natural light and views to the exterior are generally acknowledged as being important for health, wellbeing and worker productivity, appears not to be reflected in the codes of all countries. The authors point out that The New Zealand Building Code is quite unequivocal on the issue, in stating its objective "... to safeguard people from illness or loss of amenity due to isolation from natural light and the outside environment" (NZBC, 2004:Approved Document G7).

The authors also point out, however, that this is limited to habitable spaces, and does not include the majority of workplaces. The fact that the NZBC is a performance-based, non-prescriptive code, is also significant, and tends towards 'liberal interpretation' by property developers and the like. By contrast, in Germany the codes are very much more prescriptive, with strict requirements in regard to both external view and access to daylight. For example, although some exceptions are permitted, such as darkrooms and basement shops, bars and restaurants, there are strict requirements for the design of workplaces. The following

requirements serve as examples to illustrate the prescriptive nature of the German codes:

"In the Federal Republic of Germany, federal regulations for workplaces ... demand that each employee must have a view to the outside ... a window area of at least 1.25 m² (is required) for workspaces up to 5 metres deep, and a window area of at least 1.5 m² for rooms more than 5 metres deep. In addition, for rooms of up to 600 m² floor area, the total window area shall be at least 10 percent of the floor area, for rooms with a floor area of more than 600 m² the total window area shall be at least 60 m² plus one percent of the floor area. The window sill shall be located between 0.85 and 1.25 metres above the floor level of the room, and the transparent part of the window shall be at least one metre wide and at least 1.25 metres high" (Osterhaus & Donn, 1998).

Perhaps not surprisingly, in a country where legislation ensures access for all workers to both natural light and exterior view, the code compliance requirements in Germany seem to largely negate the need for core-daylighting systems. Compulsion means that the solution is sought in the initial building planning, rather than in adding components retrospectively. "German office buildings generally have little depth. The most common configuration is a central corridor with offices on both sides. Rarely does the depth of the offices on either side exceed 5 metres" (Osterhaus & Donn, 1998).

Their paper concludes by suggesting that daylighting design should become an integral part of future lighting codes and standards, particularly in the design of offices and other workplaces.

Daylighting Design - The Role of the Architect

To conclude this paper, consideration will be given to the role of the architect, and the relationship between architect, building user, and other professionals working in the arena of daylighting. As with many issues in architectural design, the primary aim must be to meet the specific needs of users. At the basic level in considering what these needs may be, Evans (1981) believes there is failure, on the part of both architect and building owner, to examine and address specific visual task needs at the design stage. User needs, however, go much more deeply than the ability to carry out visual tasks, into considering the overall comfort, health and wellbeing of the building's occupants. As discussed earlier, Gallagher (1999) and Cherulink (1993) believe that architects need to show more interest in the findings of environmental behavioural research, and to be more proactive in adopting some of the findings.

There is something of a grey area in all of this debate, however, and the question needs to be asked, "how far can the architect go in assessing and judging user needs, or is this the realm of another professional?" In answering this, and speaking from his standpoint as a lighting engineer and designer, Hopkinson (1963) is quite unequivocal in his view. He believes that establishing the needs, per se, of people, falls firmly within the arena of the psychologist, and that the architect's role is to provide the environment necessary to meet these needs. He suggests that "the architect's task of creating a favourable environment for living and working demands a study of the response of the human being to this environment. Such a study is new

as a science, though not as an art" (Hopkinson, 1963:3).

Cook (1997) believes that the understanding of daylighting techniques could well become an important aspect of the architect's services, and that more clients are likely in the future to seek this form of expertise. Hopkinson (1963) also emphasises the important role played by the architect, though he sees it more as assimilating the engineer's expertise into design solutions. Writing exactly one decade before the first oil crisis, Hopkinson suggests a more responsible and pro-active approach be taken by architects, and that the 'seat of the pants' approach must be underpinned by the more scientific expertise. "Lighting and glare, acoustics and noise, etc, ... are all matters to be studied by a new kind of specialist, although the application of the results of all these experimental studies lies with the architect" (Hopkinson, 1963:3).

Ander (1995) makes a strong plea to building design consultants to work cooperatively and for all disciplines to become involved at an early stage in the design process. This, he considers, gives the best chance for all aspects to be properly considered and integrated. In considering what the best approach might be to the successful integration of daylight in architectural design, Moore (1995) introduces the idea by suggesting that "...daylighting is the most recently discovered realm of architecture. Once inseparable from the practice of fine building design, lighting by natural means began to be regarded as anachronistic early in the twentieth century when electric lighting became both practical and economical. Instant, safe, predictable, and absolute, artificial lighting has tended to overwhelm building

design since the Industrial Revolution. Electricity has also made possible constant illumination levels that do not reflect the natural rhythms and the unpredictable variations of each day's new light" (Moore, 1995:(vii)).

Ander considers that there is an intimate relationship "between people, daylight and architectural form, with daylight being the 'design variable'" (Ander, 1995:(vii)), and consequently the most significant element in determining the form and scale of the building, its orientation on the site, and the interior spaces, both in terms of the quality and character of those spaces, and in how the occupants respond to those spaces.

Selkowitz (1998) suggests that technological advances, such as more efficient types of glazing, will be insufficient to change mindset, and he believes that the process needs to be much more holistic in nature: "Daylighting is fundamentally a systems integration challenge, involving the building siting and orientation, fenestration design, lighting systems design, control systems selection, and ongoing maintenance" (Selkowitz, 1998:2).

Lam (1986) essentially agrees with this viewpoint, and he suggests that designing for sunlight involves careful architectural design in terms of both the planning and the geometric forms relative to the light available. He also suggests that an overall understanding is needed on the part of the designer, of the nature of light, and the methods of controlling light, and the ability to relate this to an architectural context. He cites the Cambridge University History Faculty building by James Stirling as an example of failure to address environmental concerns

(Figure 6). "Many of the best known architects have created dramatic toplighted sculptural statements that must have assumed sunless skies and then attempted to ameliorate the self imposed problems with technical solutions, sometimes with little success. One example is the fully glazed greenhouse ceiling/roof at the Cambridge University History Faculty building (James Stirling, 1967). This building is an environmental disaster, cold and drafty in winter and hot as an oven in summer" (Lam, 1986:142).

Conclusion

The importance of looking at the whole building cannot be over emphasised. Thomas (1996), much like Lam, and Baker and Steemers (2000), acknowledges what he terms "the most significant shift in thinking," which is to consider the building in its entirety. This more holistic approach gives careful consideration to aspects such as the initial siting of the building, its eventual form, and the structure and materials used for construction and finishes. He considers



Figure 6: Built in the 1960s, a time when environmental concerns played little or no part in the design of buildings, the Cambridge University History Faculty was effectively a giant glasshouse – more than enough daylight, but too hot in summer, too cold in winter. Paradoxically the building was awarded a Gold Medal by the RIBA in 1966 (Source: webmaster@hist.cam.ac.uk).

that daylight has become important as a consideration in building design, to the extent that the design should “aim to provide enough light whenever the sun is above the horizon” (Thomas, 1996:6).

The best of intentions may not always come to fruition, however, and a whole range of conditions can sometimes conspire to make it very difficult to provide optimum natural lighting conditions deeply within a building. These ‘conditions’ might include a deeper than normal floor plan, or a less than ideal site, which, for example, may be heavily shaded by adjacent hilly terrain, tall trees or other buildings and structures. It is in this area that considerable work has been done over the past two decades, to develop a range of systems and methods to facilitate interior daylighting by re-direction of natural light. This topic has been covered in some depth by the author in an earlier paper (Barrett, 2007), in which a range of these systems and methods is catalogued and discussed. These range from simple devices such as skylights and light shelves,

through to more complex computerised sun-tracking mirror and prism systems (heliostats). Much of this innovative development has been carried out by Dr Paul Littlefair of the United Kingdom Building Research Establishment, and his research includes some historical precedents as illustrated by figure 7, indicating that light re-direction is nothing new (Littlefair, 1996). This also throws out a challenge to architects, to think creatively about natural lighting of deep interior spaces, rather than take the easy alternative of relying on artificial illumination.

As architects we would also do well to acknowledge the inspiring legacy left to us by the likes of Khan, Le Corbusier, and others. We should also recognise that a few contemporary architects (such as Steven Holl, and Lord Norman Foster), have taken up the reins, and continue to work within the principle that “... light inspires us and can enliven space. There are few things as delightful as the ever changing presence of natural light in a building. Natural light tells us about the weather, the time of day,



Figure 7: As London's narrow streets developed, little attention was given to making best use of natural light. An exception was this factory building in Ironmonger Lane, where early examples of light scoops were fitted to help improve working conditions inside the building (Source: Littlefair (1996), p 13.).

and satisfies other deeply rooted psychological needs" (Egan & Olgyay, 2002:88).

References

- Ander, G. (1995). Daylighting performance and design. New York: Van Nostrand Reinhold.
- Baker, N., & Steemers, K. (2002). Daylight design of buildings. London: James & James.
- Barrett, R.J. (2003). Daylight & deep architectural space (Master of Architecture dissertation, Victoria University of Wellington, Wellington, New Zealand, 2003).
- Barrett, R.J. (2007). How well do New Zealand architects understand systems and methods for re-directing natural light into deep windowless spaces of buildings? *Architectural Science Review*, 50(2), 163-172.
- Building Industry Authority (NZ), New Zealand Building Code. (1992). The building code handbook & approved documents, Wellington, New Zealand: Author.
- Buttiker, U. (1994). Louis I Khan: Light and space, New York: Whitney Library of Design.
- Cherulink, P.D. (1993). Applications of Environment-Behaviour Research: Case studies and Analysis. New York: Cambridge University Press.
- Collins, B.L. (1975). Windows and people: A literature survey (psychological reaction to environments with and without windows). Washington: Department of Commerce, Institute for Applied Technology, National Bureau of Standards.
- Cook, A. (1997). Living daylighting. *Journal of Royal Institute of British Architects*, 104(9), 96-99.
- Copplestone, T. (1997). Frank Lloyd Wright: A retrospective view. Broxbourne, England: Regency House Publishing Ltd.
- Day, C. (1990). Places of the soul: Architecture and environmental design as a healing art. London: Aquarian / Thorsons-Harper Collins.
- Department of Building & Housing (NZ), New Zealand Building Code. (2004). The building code handbook & approved documents. Wellington, New Zealand: Department of Building & Housing: Author.
- Egan, M.D., & Olgyay, V. (2002). Architectural lighting. New York: McGraw-Hill Book Company.
- Evans, B. H. (1981). Daylight in architecture. New York: Architectural Record Books, McGraw-Hill Book Company.
- Gallagher, W. (1994). The power of place: how our surroundings shape our thoughts, emotions and actions. New York: Harper Perennial Library.
- Gallagher, W. (1999). How places affect people. *Architectural Record*, 187(2), 75-78.
- Hopkinson, R. G. (1963). Architectural physics: lighting. London: Her Majesty's Stationery Office.
- Hopkinson, R.G., Petherbridge, P., & Longmore, J. (1966). Daylighting. London: Heinemann.
- Lam, W.M.C. (1992). Perception and lighting as formgiver for architecture. New York: Van Nostrand Reinhold Company.
- Lam, W.M.C. (1986). Sunlighting as formgiver for architecture. New York: Van Nostrand Rheinhold Company.
- Littlefair, P.J. (1996). Designing with innovative daylighting. Garston, England: Building Research Establishment.
- MacLaughlan, J., Anderson, M., & Hollick, F. (1982). Discussion paper: spectral character of sunlight modulates photosynthesis of previtamin D3 and its photoisomers in human skin. Cambridge, MA: Massachusetts Institute of Technology.

Moore, F. (1995). Concepts and practice of architectural daylighting. New York: Van Nostrand Reinhold Company.

Osterhaus, W., & Donn, M. (1998). Discussion paper: Is the obvious not obvious enough? Centre for Building Performance Research, School of Architecture Victoria University of Wellington: Wellington, New Zealand.

Rangi, K., & Osterhaus, W. (1999). Discussion paper, windowless environments: are they affecting our health? Wellington, New Zealand: Centre for Building Performance Research, School of Architecture, Victoria University of Wellington.

Rasmussen, S.E. (1964). Experiencing architecture. London: Chapman & Hall Ltd.

Ruck, N.C. (1989). Building design and human performance. New York: Van Nostrand Reinhold Company.

Selkowitz, S. (1998). Proceedings from Daylighting '98': The elusive challenge of daylighted buildings. Ottawa, Canada.

Stegers, R. (2008). Sacred buildings: a design manual. Basel, Switzerland: Birkhäuser.

Thomas, R. (1996). Environmental design: an introduction for architects and engineers. London: E & F N Spon, Taylor Francis Group.

Richard Barrett

Richard Barrett is a practising architect and a Senior Lecturer and former Chair of Research at the School of Architectural Studies, Christchurch Polytechnic Institute of Technology, Christchurch, New Zealand. He graduated from the School of Architecture, City of Leicester Polytechnic (UK) in 1971. In 2003 he was awarded a Master of Architecture degree (with Merit) by Victoria University of Wellington, New Zealand. His interest in the subject matter for his masters thesis, 'core-daylighting' (systems and methods for bringing natural light into deep architectural space where conventional methods such as windows and skylights cannot readily be used), was sparked during the early 1980s whilst working as architect for the redevelopment of New Zealand's Scott Base in Antarctica. Barrett visited the continent to monitor construction, and the experience of living in constant daylight, with no apparent diurnal-nocturnal rhythm to pace daily activities, led to an interest in the physical and physiological influence brought about by natural light (or its lack), and in particular the role played by architecture in this process. This culminated in his Masters thesis (Barrett, 2003) which examined the state of the art amongst New Zealand architects. He is an Associate Member of the New Zealand Institute of Architects, and committee member of the NZIA Canterbury/Westland Branch. He can be contacted at barretr@cpiit.ac.nz